5.0 GROUND-BASED INERTING

The GBIS concept is based on the idea of purging the ullage of a fuel tank with NEA provided from a ground source. This externally supplied NEA will be delivered to the airplane at a given purity and pressure. The NEA is generated through hollow-fiber membrane separation technology, which does not affect the airplane's GBIS design.

Either a fixed installation at the gate or a dedicated truck will supply the NEA. Tests carried out for each applicable airplane model will determine the amount of NEA required to reduce the oxygen concentration in the tank ullage to the inert level. Maintaining the added NEA volume at a fixed amount for each different airplane type—regardless of fuel load—to be specified on a placard directly adjacent to the airplane's servicing interface will simplify operations and reduce the risk of loading incorrect quantities of NEA. This also allows for inerting to be performed before, during, or after fueling, without affecting the volume of nitrogen required.

A dedicated distribution pipe network permanently installed on the airplane will discharge the NEA into the required fuel tank. Dedicated equipment and controls will ensure that no unacceptable hazard is introduced into the airplane. At the end of the inerting procedure, the tank ullage will be at a maximum of 8% oxygen by volume.

After this process has been carried out, the tanks will remain inert on the ground for a minimum of 2 hr. After takeoff and climb, fresh air will be drawn into the tanks as fuel is consumed, which will dilute the concentration of NEA in the tank ullage.

Tests have shown that tanks containing low or only residual fuel quantities may remain inert throughout the cruise portion of the flight, as long as no altitude reductions are made. As a part of the GBI incorporation, testing has shown that it is necessary to modify vent systems of some airplane designs to eliminate crossflow through the tank from multiple-vent outlets.

The Tasking Statement defines tanks required to be inerted as those that do not cool at a rate similar to a wing tank, which includes CWTs—heated or unheated—and fuselage auxiliary tanks.

5.1 CONCEPT DESCRIPTION

The final design of the system will be airplane specific and reflect the basic design philosophies and principles of the manufacturer. This generic study uses a system that incorporates the features likely to be necessary on a typical installation. As illustrated in figure 5-1, this system concept is relatively simple.

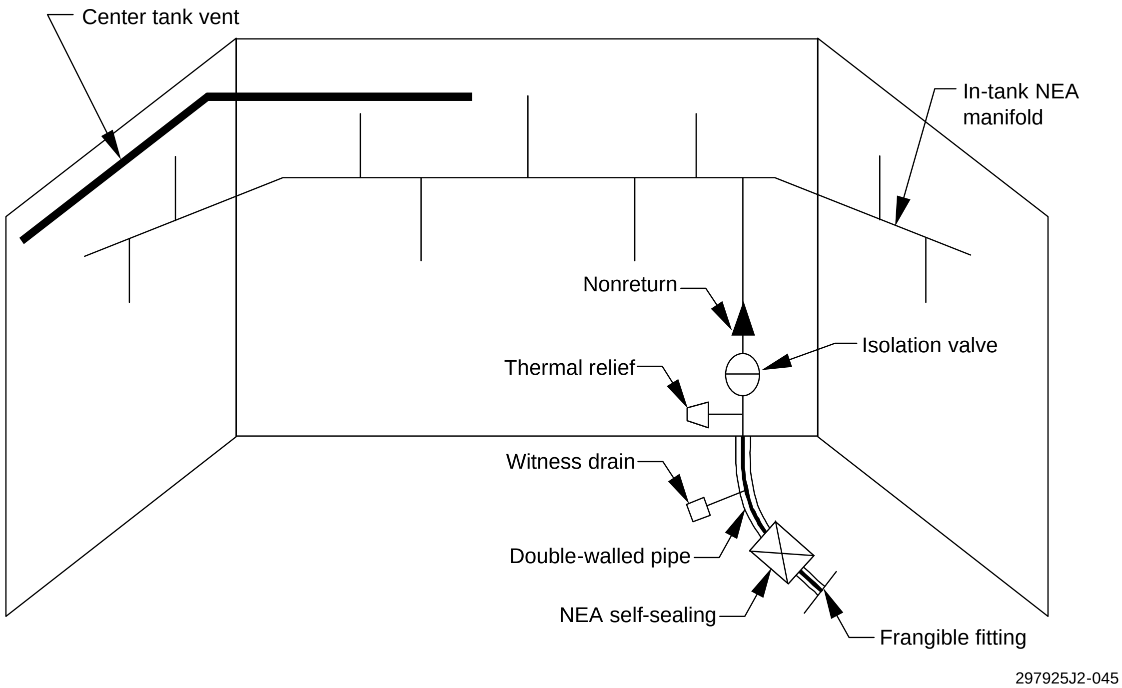


Figure 5-1. Center Tank Installation Concept

A dedicated truck or airport distribution network supplies NEA to the airplane. A new dedicated connection point and service panel will be incorporated into the airplane. The preferred location for this panel is the wing-to-body fairing. The connection point will use a new standard of coupling that ensures that there is no possibility of cross-connection with any other servicing connectors. The service panel will allow all operations associated with inerting the tanks to be carried out. It will comprise a switch to control the isolation valve and a valve position indication lamp.

From the airplane connection point, the NEA will be distributed to the center tank and additional internal or auxiliary tanks if the airplane is so equipped. Where any nitrogen plumbing has to pass within the pressurized compartment or an area of restricted ventilation, the double-walled pipes will minimize the risk of leakage into any confined area.

Within the tank, a dedicated manifold will distribute the NEA. Reviewing the various airplanes included in the study indicated that the type of internal structure could vary between airplane models. On some airplane types, ribs divide the applicable tanks into discrete cells, whereas on other types the tanks are basically open. The detail design of the manifold is airplane specific, but will generally comprise a series of pipes and outlets.

The use of a dedicated manifold allows the inerting operation to be performed before, during, or after the refueling operation. Mounting the manifold close to the top of the tank ensures that maximum mixing occurs and was shown in testing of one model to efficiently purge the ullage of oxygen to 8%, with 1.7 volumes of 95% NEA.

Close to the tank wall, the tank is isolated from the filling manifold. A frangible coupling at the airplane connection point will be provided in case the ground equipment is moved while still attached to the airplane. A self-sealing coupling may be incorporated within the frangible coupling at the connection point. A simple nonreturn valve will prevent the possibility of fuel backflow from the tank.

The generic system also incorporates the following additional equipment:

- A witness drain to detect any leakage in the double-walled pipe.
- A thermal relief valve to prevent pressure buildup in the pipe between the connection point and isolation valve.

Connecting the NEA supply to the airplane and opening the isolation valve is all that will be required to inert the tanks. When the appropriate quantity of NEA has been added, the isolation valve will be shut and the NEA supply disconnected.

To confirm that the inerting operation has been carried out, the person responsible must record the volume of NEA supplied to the airplane and provide this record to the flight crew, who will compare it to the volume contained in the flight manual or on the load sheet.

5.1.1 Auxiliary Tanks

A number of auxiliary tank configurations were reviewed, comprising installations in which the tanks are located in either or both the forward and rear cargo compartments. This review led to the conclusion that, for airplanes fitted with auxiliary tanks, a similar system arrangement and operation to that proposed for CWTs would be used.

A single NEA connection point with the previously described features will supply both the CWT and any auxiliary tanks installed.

From the connection point, the pipe will branch to the center tank and to the auxiliary tanks. The final layout will be airplane specific. The auxiliary tanks will include the same features as the CWT design (i.e., a means of isolating the tank, a nonreturn valve, and a dedicated manifold to distribute the NEA), as shown in figure 5-2.

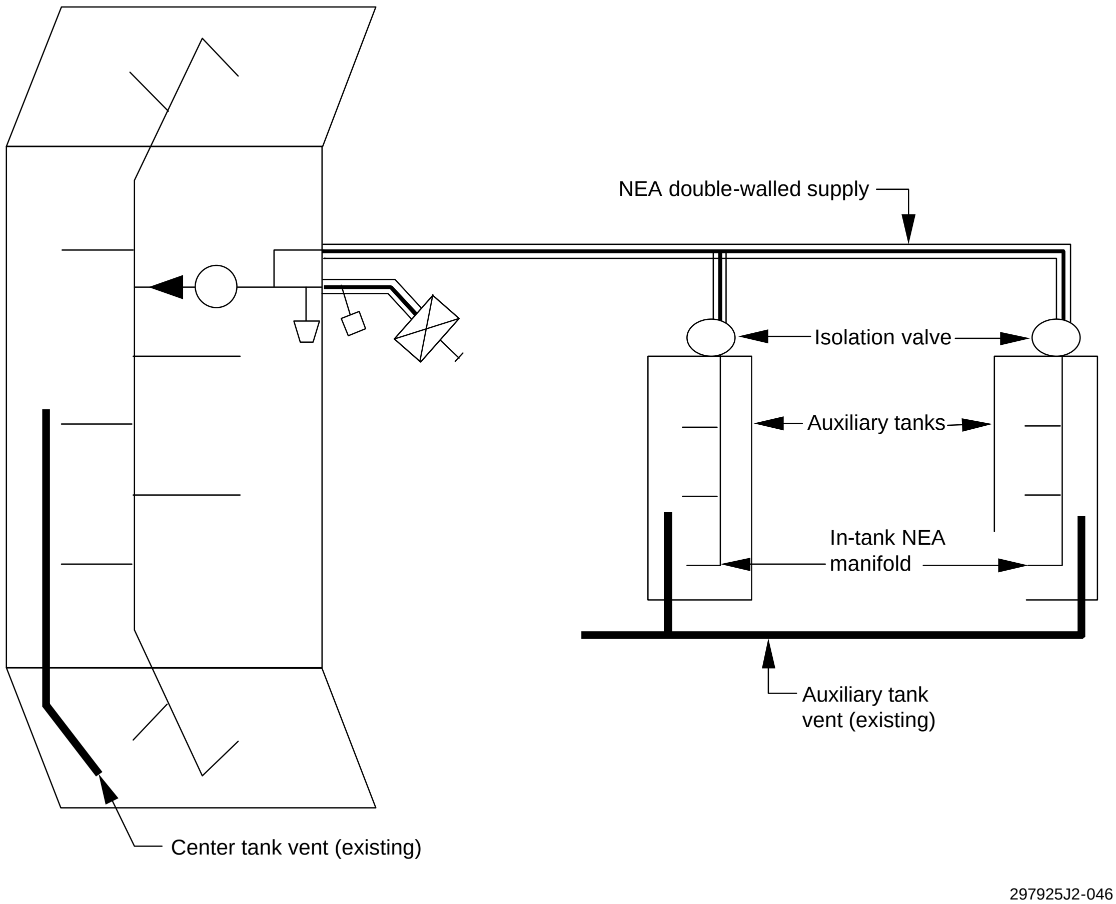


Figure 5-2. Center and Auxiliary Tank Installation Concept

Inerting the auxiliary tanks at the same time as the CWT will minimize any impact on turnaround times. The procedure for the auxiliary tanks will be the same as for the CWT, in that a fixed volume of NEA will be introduced into the tank.

Ensuring that each tank receives the appropriate quantity of NEA may require creating orifices or providing some additional control of the NEA tank isolation valve on the auxiliary and CWTs, depending on the final geometry of the installation and the supply pressure.

Auxiliary tank installation will require a weight increase of approximately 45 lb for each ARAC generic airplane, regardless of size. The system weights are driven primarily by the weight of the double-walled pipework between the connection point and the tank inlet. The weight for the smaller airplane also reflects the installation of auxiliary fuel tanks in both the forward and aft cargo bays.

5.2 APPLICABILITY TO STUDY-CATEGORY AIRPLANES

In compliance with the FAA Tasking Statement, the proposed system design, control, and operation are applicable to all airplane fuel tank types that do not cool at a rate similar to a wing tank. New airplane types will incorporate the requirements during the initial design phase. In-production airplanes will be redesigned for incorporation during the production cycle. Service bulletin (SB) action will cover in-service airplanes within the time prescribed by the regulation.

5.3 AIRPORT RESOURCES SYSTEM REQUIRED

The GBIS is designed to accept airport-supplied NEA from either a fixed installation or a mobile truck. The system design ensures that the fuel tank is inerted within 10 to 20 min. Inerting times have been selected to eliminate or minimize any gate delays.

Ground equipment will control the NEA supply to a maximum acceptable pressure value. For most airplanes, this study shows that the supply pressure must be limited to a maximum of 5 psig. Even at this pressure, a small number of airplane types will still require the installation of additional onboard equipment to further reduce the pressure to an acceptable level.

The purity level of NEA supplied will need to be agreed and standardized for the worldwide airplane fleet, because this value will be used to determine the amount of NEA required during each airplane type certification.

For this study, we have assumed that the amount of NEA required to inert an aircraft fuel tank is 1.7 times the tank volume. This assumes that 95% pure NEA is supplied, achieving a final oxygen concentration within the tank of 8%. This value has been selected as a base on a limited number of tests performed on a Boeing Next-Generation 737 airplane. It should be noted that this factor would vary with each airplane category.

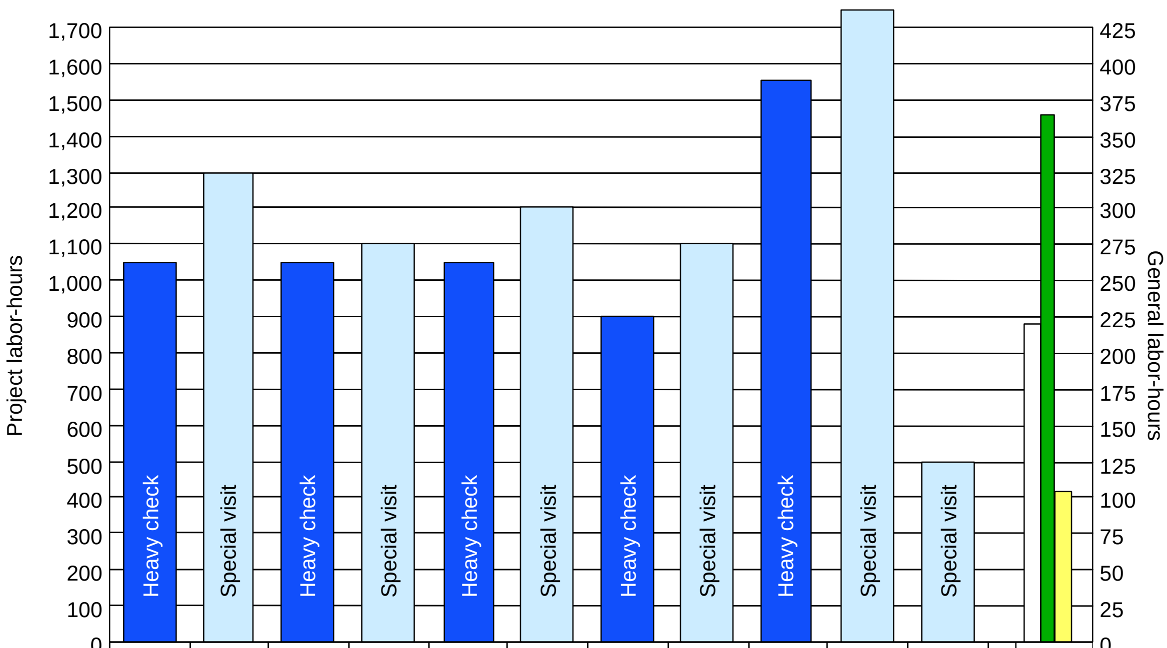
Available data suggests that the discharge of NEA from the airplane vents does not require any special precautions or procedures.

5.4 AIRPORT OPERATIONS AND MAINTENANCE IMPACT

This section discusses the modification of in-service airplanes to install a GBIS and the overall effect of GBI systems on airplane operations and maintenance requirements.

5.4.1 Modification

Figure 5-3 shows the modification estimates for the GBIS. For all airplane categories, estimates are shown for both a regular heavy maintenance visit and a special visit. For corporate and business airplanes (FAR Part 91 operators), the modifications would likely be accomplished during special visits to factory service centers. Consequently, the figure shows special-visit estimates only for corporate and business airplanes.



Legend:	Large	Large	Medium	Medium	Small	Small	Regional fan integral	Regional fan integral	Regional fan bagtank	Regional fan bagtank	Business jets 1e		General
Project time	1,050	1,300	1,050	1,100	1,050	1,200	900	1,100	1,550	1,750	500		
Engineering													220
Tech pubs													365
Material control													104
Training													
Flight ops eng													

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Figure 5-3. Modification Estimates for Ground-Based Inerting Systems

Estimates for regional turbofan airplanes with bladder tanks (rubber cells) are made as well. Previous sections explain that such tanks were not taken into account. However, we felt that this estimate had to be made to obtain an idea of how many extra labor-hours would be required for the project.

No estimates have been made for regional turboprop airplanes, because no company that does the maintenance for turboprop airplanes with a CWT could be located or consulted. According to Fokker Services, who did the estimates for the regional turbofan airplanes, there are very few if any turboprop airplanes that have a CWT.

The left side of figure 5-3 shows estimated project labor-hours for the different airplane categories. General labor-hours are shown on the right. These labor-hours are the same for all airplane categories.

5.4.2 Scheduled Maintenance

Scheduled Maintenance Tasks

A list of scheduled maintenance tasks was developed using the GBIS schematic provided by the Ground-Based Inerting Designs Task Team. Each component illustrated in the schematic was individually evaluated and tasks were written accordingly. These tasks included inspections, replacements, and operational and functional checks of the various components that make up the system. These tasks were assigned to the various scheduled checks (A, C, 2C, and heavy), and labor-hours for each task were estimated. The estimates assume that tasks completed at an A-check would also be completed at a C-check. Similar assumptions were made for the C- and 2C-check tasks (i.e., that they would be accomplished at the 2C- and heavy checks, respectively). Appendix F, addendum F.B.1, lists these tasks.

Additional Maintenance Labor-Hours

Figure 5-4 shows the estimated additional scheduled maintenance labor-hours required at each check to maintain a GBIS.

Airplane category	Additional A-check hours	Additional C-check hours	Additional 2C-check hours	Additional heavy check hours	Average additional labor-hours per year
Business jet	2	5	7	17	16.46
Turboprop	2	5	7	17	16.46
Turbofan	2	5	15	17	17.21
Small	2	5	17	17	34.65
Medium	2	5	21	21	32.93
Large	2	5	25	25	34.74

Figure 5-4. GBI Additional Scheduled Maintenance Hours

5.4.3 Unscheduled Maintenance

In accordance with the Tasking Statement, the design of the GBIS is based on inerting fuel tanks that are near significant heat sources or that do not cool at a rate equivalent to an unheated CWT. The design concept for the GBIS considered only CWTs and auxiliary tanks. In addition, because the GBIS operates only on the ground, the system operation time was based on the minimum turn times discussed later in this report. The basic design of a GBIS for airplanes without auxiliary tanks is relatively simple. The detailed design concept was discussed previously in this report. A reliability and maintainability analysis evaluated the following system components:

- Nonreturn valve.
- Isolation valve with integral thermal relief valve.
- Self-sealing coupling incorporating a frangible fitting.
- Ducting (including distribution manifold and double-walled tubing).
- Wiring.

For airplanes with center wing and auxiliary tanks, the system components include the same components as a CWT-only installation, with the addition of one nonreturn valve and one isolation valve per auxiliary tank plus interconnect ducting. Including auxiliary tanks in the reliability and maintainability analysis will have a minimal effect because it would simply increase the quantity of nonreturn and isolation valves, depending on the number of auxiliary tanks installed. This would affect the component MTBUR for the nonreturn valve and isolation valve. However, the exclusion of the auxiliary tank components is considered well within the margin of error of the total system analysis. Just the CWT components noted above were considered in the analysis.

The system design concept took into consideration the need for a pressure-regulating valve (PRV), which would limit the delivery pressure of the NEA on some business jets and regional airplanes resulting from fuel tank construction. Conceptually, the PRV could be part of either the airplane system or the airport delivery equipment. Because of this and the limited applicability of the PRV, this analysis did not evaluate this component.

As with each of the system design concepts, component reliability was evaluated based on similar components. Once the individual component MTBUR was determined, the system MTBUR was estimated to be 9,783 hr. Because of the system's simplicity, the GBIS had the highest level of reliability and is the only system with reliability levels considered acceptable for commercial airplane operations.

Each of the six study airplane categories used the system MTBUR. There was no attempt to determine whether the system MTBUR would vary between the different airplane categories because of system size or operational differences. Any differences were well within the margin of error used to calculate the system MTBUR.

The system annual failure rate was calculated based on the respective system MTBURs and yearly use rates for the airplane category. Section 10 describes the annual delay time as based on a standard delay rate assumption for each airplane category.

Each airplane category was looked at separately to determine component removal and replacement time, access time, and troubleshooting time. Figure 5-5 shows system maintenance labor-hours per year based on the summation of the individual component removal, replacement, access, and troubleshooting time multiplied by the component annual failure rate.

Category	Large	Medium	Small	Regional turbofan	Regional turboprop	Business
Annual failure rate	0.42	0.29	0.29	0.22	0.3	0.11
Standard delay rate (1 delay = XX min)	30	45	60	60	60	60
Annual delay time (min/year)	13	13	17	13	18	7
Unscheduled maintenance labor (hr/year)	3.13	1.96	2.02	1.35	1.89	0.77

Figure 5-5. GBIS Reliability and Maintainability Analysis

System weights provided by the design team determined the cost-to-carry value for the GBIS. System weights were provided for large, medium, and small airplanes, including weights of the components listed above and other equipment not included in the analysis, such as brackets and ground straps. The calculated cost-to-carry values (fig. 5-6) represent the costs associated with the additional weight of the system over 1 year of operation. Calculated from the system weight and a variable input, cost to carry per pound, per year ($) equates to additional fuel burn.

	Large	Medium	Small
System weight, pounds	54.33	34.10	22.05
Costs per pound per year, dollars*	165.53	131.80	62.00
Cost to carry, dollars per year	8,993.24	4,494.38	1,367.10

*Considered a nominal value; may differ by airline.

Figure 5-6. GBI System Cost to Carry

5.4.4 Flight Operations

GBI has the least impact on flight operations, in that there will be no onboard operating systems to monitor or control. Once the tanks are inerted on the ramp, the maintenance technician will need to inform the operating crew that the inerting has been properly completed. The object has been to design the servicing apparatus so that this function can be accomplished within the average minimum established turn times and thus not create delays, although very short scheduled turn flights could be affected.

Very little flight crew training should be necessary, but dispatch and ramp office personnel as well as the flight crew would have to be familiar with any operational limits or requirements for dispatching with the inerting system inoperative. Dispatch requirements need to be thoroughly defined with regard to conditions of non-availability of NEA supply and the existing conditions of a takeoff and flight from that station. Airport usage for scheduled or alternative operations would have to be evaluated, and route structures could be affected by nonavailability of NEA.

5.4.5 Ground Operations

The GBIS is one of the most labor intensive of all proposed inerting methods researched to date by this group. This results in part from GBI requiring that a dedicated technician be present during the inerting process while the airplane is parked on the ramp or at the gate. The GBIS is also solely dependent on airport infrastructure.

For the purposes of the gate operation, airplanes would undergo servicing procedures similar to the following:

> A technician attaches the inerting hose from a dedicated source, which may come from either the terminal (jetway) or a tanker. After the inerting value is given, the valves are opened to allow the flow of nitrogen into the tank. At the end of the operation, the technician closes the valves and completes the process. When the inerting equipment has been secured, the flight crew receives from the technician an inerting slip that verifies the flight number, date, and quantity of inerting gas loaded, along with the signature of the individual who performed the task. The flight crew then checks the quantities against the flight release. This allows normal servicing and through-flight responsibilities (e.g., logbook items and maintenance checks) to be accomplished while at the gate. Inerting times are proportional to the type of airplane.

Small airports and remote areas of large airports and maintenance facilities will use inerting trucks, which will allow fuel tank inerting when the airplane is away from the gate.

The ground inerting process is unique in that while the inerting system is not flight critical, it is one of the few airplane systems that gives the flight crew no indication or means to verify if the process has been accomplished. The person monitoring the inerting process would be solely responsible for complying with the inerting requirements. Because low-skilled personnel generally hold ground service positions, turnover rates for ground service employees are significantly higher than those for maintenance technicians. Therefore, the team concluded that the inerting would have to be accomplished by a trained maintenance technician.

During several Working Group discussions, the question was raised as to whether the ullage washing task would have to be a dedicated position. After carefully considering the task, the team concluded that, even if the system could be left unattended, it is unlikely that this short period of time could be used efficiently. If the task were to be assigned to a fueler, for example, the inert task would extend the total refueling time per airplane by an equivalent amount of time. To compensate, additional refueling personnel and equipment would have to be added.

The team discussed the reduction in costs for labor. In the early stages of airplane single-point refueling systems, specialized technicians were tasked to this work exclusively. This is still the case in in many countries. As the systems became more automated and reliable, less specialized perrsonnel were able to successfully accomplish this task. The inerting process should mirror this model. The team concluded that in the future, the job function could be reevaluated, but for the initial phase, it is imperative that this is performed by a technician.

GBI Ullage Washing Labor Estimate

The fuel tank ullage washing or inerting process is similar to and accomplished in parallel with the airplane fueling process. The Airplane Operation and Maintenance Task Team reviewed the proposed ullage washing procedure and developed a labor estimate for this process. The labor estimate uses the inerting time developed for each airplane category by the Ground-Based Inerting Designs Task Team. The technician needs 10 min to connect and disconnect the ground service unit to and from the airplane and to complete the paperwork required to approve the inerting process. The estimated time a technician needs to inert an airplane's fuel tank for each airplane category was then multiplied by the number of daily operations for each airplane type and by a 30% lost-labor rate to account for mechanics' unproductive time. Figure 5-7 shows the resulting daily and annual labor estimates for ullage washing.

GBI ullage washing labor						
Aircraft	**World daily operations**	**Inerting time per turn, min**	**Connect/disconnect time per turn, min**	**Lost labor rate**	**Labor- min-utes per turn**	**Daily labor-hours**
Business jet		15	10	0.3	36	
Turboprop	20,000	10	10	0.3	29	9,524
Turbofan	10,000	10	10	0.3	29	4,762
Small transport	48,167	10	10	0.3	29	22,937
Medium transport	5,142	15	10	0.3	36	3,061
Large transport	4,599	20	10	0.3	43	3,285
				Total daily labor hours		43,568
				Annual labor hours		15,902,355

Figure 5-7. Annual Labor Estimate for Ullage Washing

Nitrogen inerting stations could be mounted on jetways or in terminal buildings at major airports, similar to the preconditioned air systems currently in use at most major U.S. airports. Airports that currently use preconditioned air systems at the gate must consider the ramifications of placing inerting equipment in the vicinity of these units, to preclude the possibility of nitrogen being vented into the cabin.

If a centralized system is not available (e.g., at regional or smaller airports), tanker trucks or their equivalent would provide nitrogen to operators at these areas. Airplane size and flight schedules would determine the demand for these airports.

Procedures would also have to be established for airplanes that divert into stations that do not have sufficient nitrogen quantities for the inerting process.

The possibility of complications combined with experience requirements should also be considered when determining the long-term effects of both having and not having qualified technicians available to perform the inerting tasks. This may also hold true for the initial MEL process on through-flights.

Potential Future System Improvements

The basic philosophy behind GBI as discussed in this study supplies a standard volume of nitrogen to a fuel tank before each flight. This standard volume is based on an assumption of maximum ullage, or an empty tank. If the tank contains fuel, this would result in more nitrogen being used than is necessary to inert the tank. The excess nitrogen would then be discarded through the tank vent system. This philosophy satisfies the inerting requirement, but results in an increased nitrogen requirement and the release of more volatile organic compound (VOC) fuel-vapor pollutants into the atmosphere. This issue may be problematic in some of the more environmentally sensitive areas of Europe and the United States.

Adjusting the volume of nitrogen used to inert the tank based on the amount of fuel in the tank is one long-range solution. Once the fuel load for a flight is determined, the nitrogen load would also be calculated and included on the fueling sheet. This would require a change to the software used to calculate the fuel load at a one-time cost of $5,000 to $500,000 per operator, depending on the kind of fuel-load program used. Dispatchers would also need to be trained to determine the volume of NEA required. The team considered this solution as a future improvement to the GBI process. These additional costs were not taken into account in the modification estimates.

An onboard inerting computer is one possible future system improvement. The inerting computer would provide the maintenance technician the means to select a specific tank and fuel quantity. Once the information is entered, the computer calculates the proper inerting value for that tank. A monitoring function keeps the technician aware of any inerting anomalies. Sensors automatically close the inerting valves when the process is complete. Once the servicing door is closed, the computer could also provide a signal to the flight deck in case of inerting or system discrepancies. Built-in test equipment at the panel could also allow technicians to test line-replaceable units and perform maintenance checks. Such a system may streamline the inerting process.

5.5 SAFETY ASSESSMENT

5.5.1 Flammability Exposure Analysis of GBI

The methodology of analyzing flammability exposure is explained in section 4.2.2, Flammability Exposure Analysis. Using this modeling approach, the effects of GBI relative to the baseline flammability for the large, medium, and small transport categories are shown in figure 5-8. As noted in the discussion on modeling in section 4, these values do not represent any specific airplane, only a generic configuration selected to represent an airplane in this category. More detail about the analysis is provided in appendix C, Ground-Based Design Task Team Final Report.

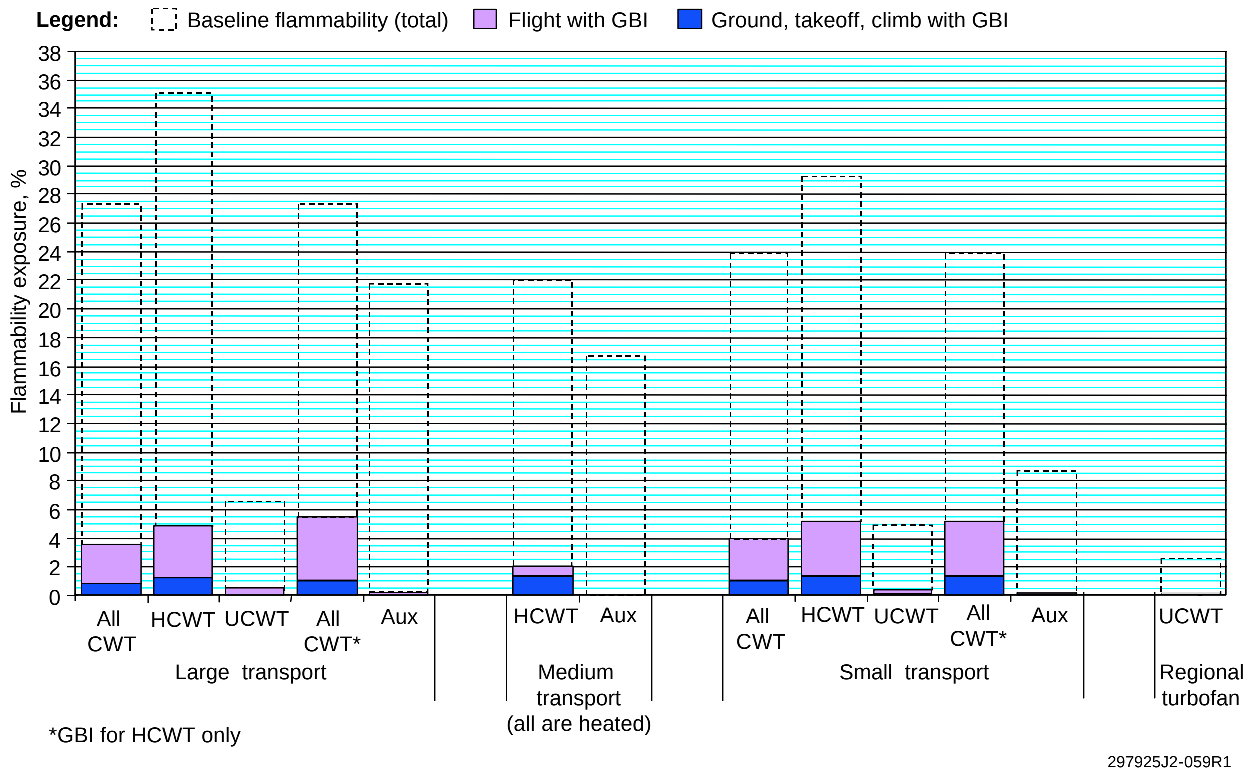

Figure 5-8. Flammability Exposure Results, Ground-Based Inerting System

The "All CWT" values represent a combination (in accordance with the ARAC estimated distribution) of the values for the heated CWTs and the unheated CWTs. Also shown are the individual values for the heated CWT- and the unheated CWT-generic airplanes.

The Tasking Statement also asks for the effect of limiting GBI to airplanes with adjacent heat sources (referred to in this report as heated CWTs) only. As shown in figure 5-8, the largest flammability reduction is for heated CWT airplanes, because the baseline flammability of the unheated CWT airplanes is already similar to the heated CWT with GBI. Therefore, limiting GBI to airplanes with heated CWTs would result in only a modest increase in fleetwide flammability exposure. Note that use of GBI for only heated CWTs is evaluated as scenario 11 and is used in the executive summary information.

Unpressurized auxiliary tanks were also evaluated; the results are shown in figure 5-8. As shown, for airplanes with unpressurized auxiliary tanks, GBI would significantly reduce the flammability. These numbers do not apply to those tanks that use pressure to transfer fuel to other tanks and remain pressurized at altitude. Because auxiliary tanks typically are not exposed to external heat sources, they typically are not flammable on the ground. Maintaining a higher ullage pressure in the auxiliary tank avoids most of the decrease in the LFL that otherwise occurs during climb, and thus most of the auxiliary tank flammability exposure. An analysis of the effects of pressurized auxiliary tanks can be found in the Ground Based Inerting Task Team Report appendix. The analysis shows that use of pressurized auxiliary tanks can result in a reduction in flammability similar to that of GBI.

5.5.2 Safety Assessment of GBI

Figures 5-9 and 5-10 show the potential impact of GBI on reducing future accidents in the United States and worldwide. If GBI is adopted, the forecast assumes that it will be fully implemented by the year 2015. At that time, the forecast indicates the time between accidents in the United States would be 16 years with the SFAR alone, 36 years with SFAR and inerting in heated CWTs, and 38 years with the SFAR and inerting in all fuselage tanks. The corresponding times between accidents for the worldwide fleet would be about half those estimated for the U.S. fleet.

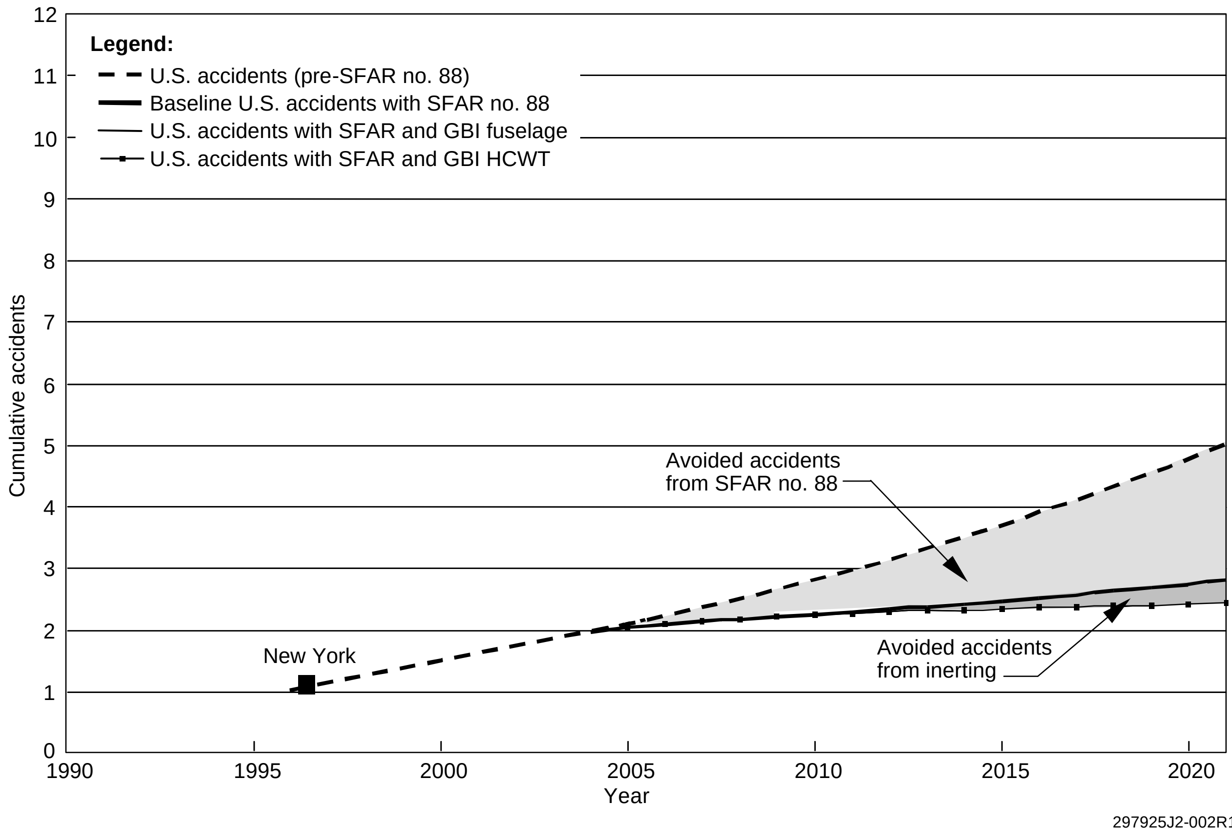

Figure 5-9. U.S. Cumulative Accidents With Ground-Based Inerting

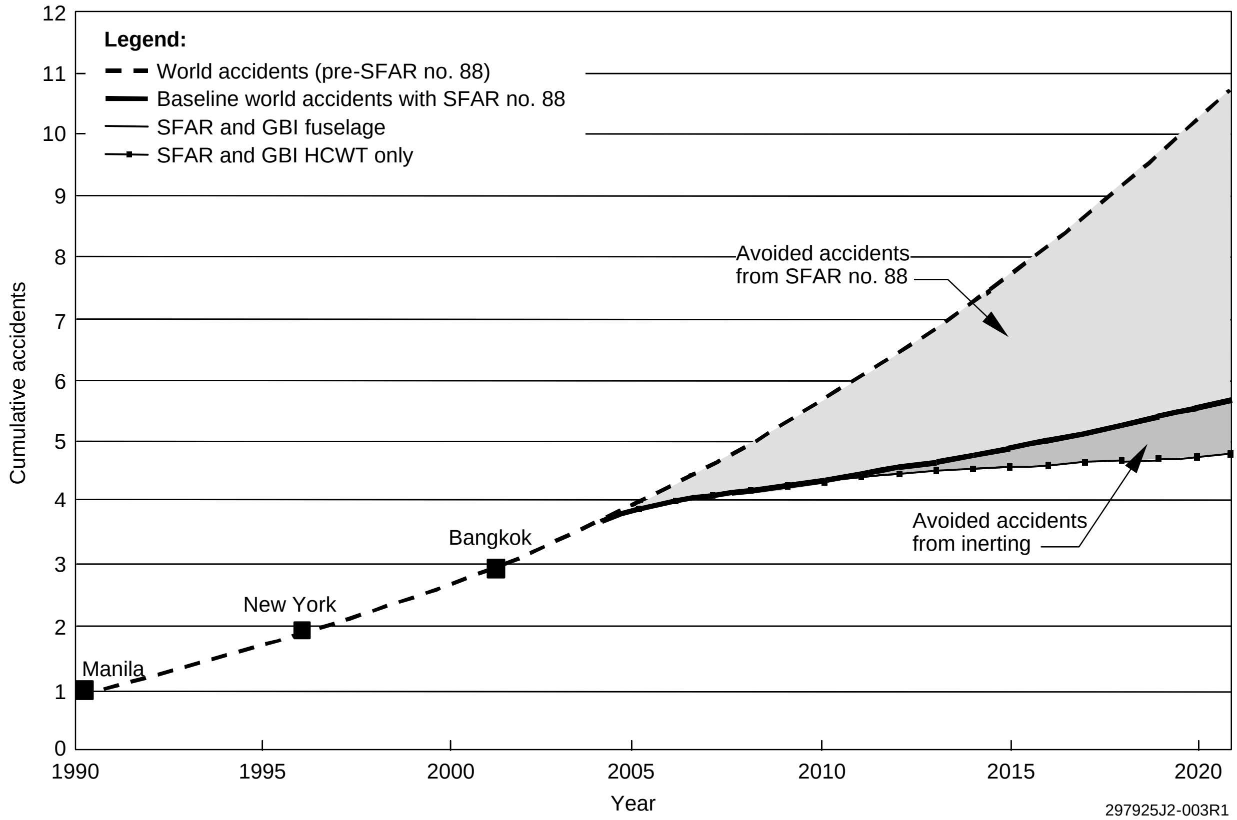

Figure 5-10. Worldwide Cumulative Accidents With Ground-Based Inerting

5.6 COST-BENEFIT ANALYSIS

Figures 5-11 though 5-18 graphically represent the cost-benefit analyses of the scenario combination examined for ground-based fuel tank inerting.

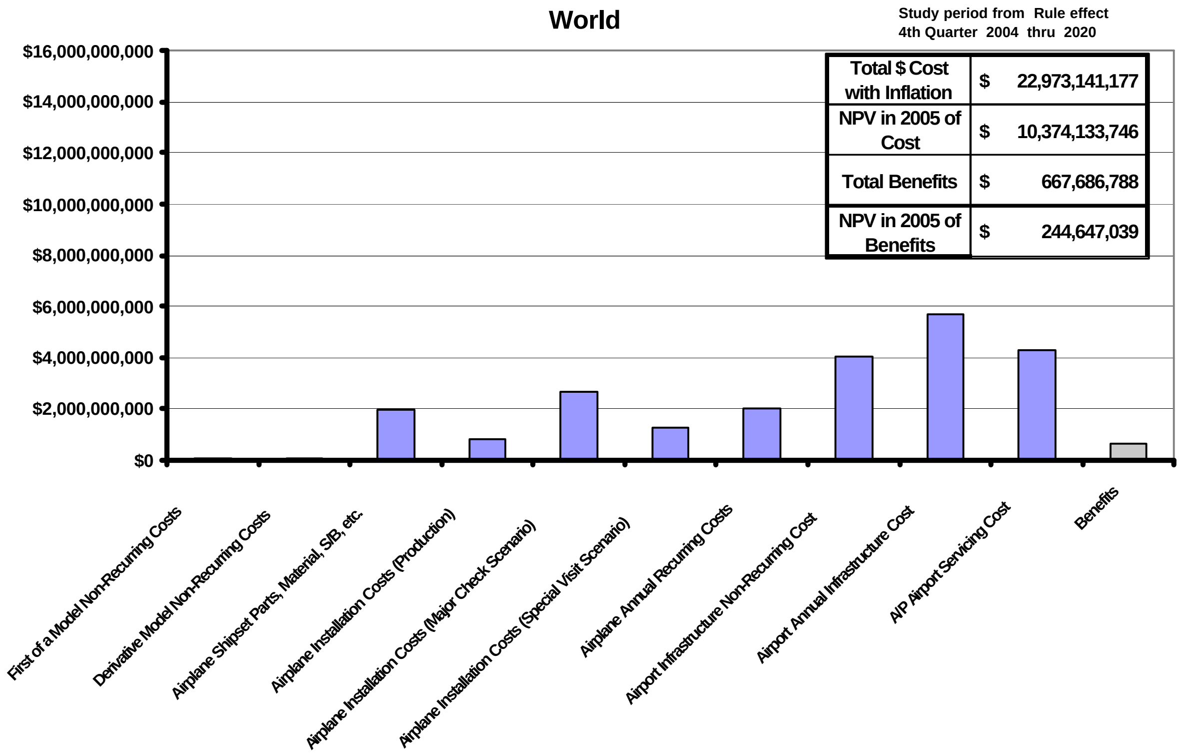

Figure 5-11. Scenario 11—Ground-Based Inerting, HCWT Only, All Transports (World)

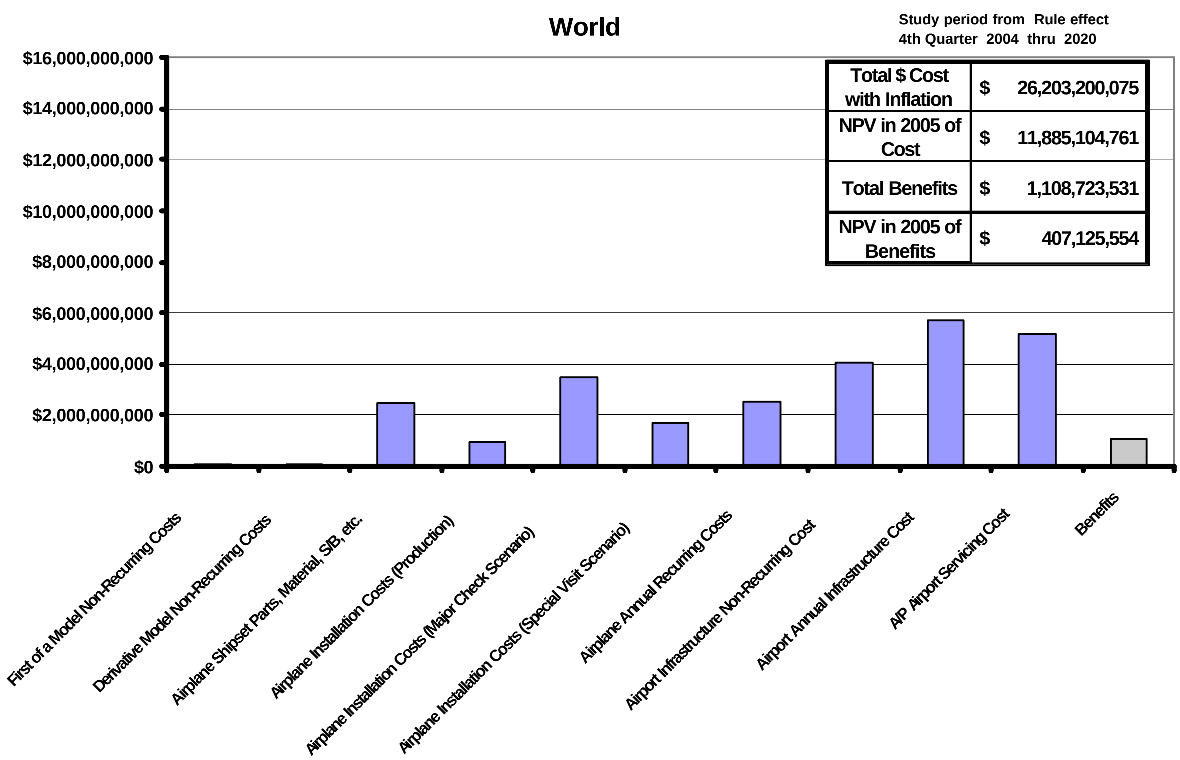

Figure 5-12. Scenario 12—Ground-Based Inerting, All Fuselage Tanks, All Transports (World)

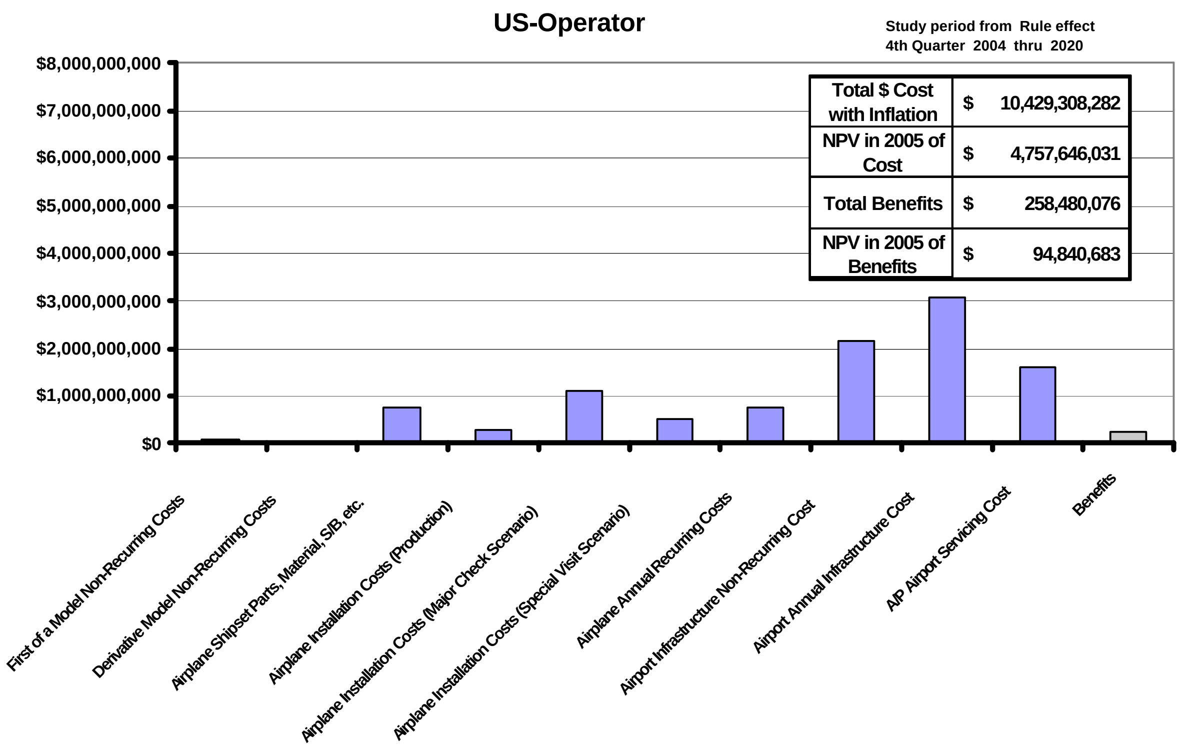

Figure 5-13. Scenario 11—Ground-Based Inerting, HCWT Only, All Transports (U.S.)

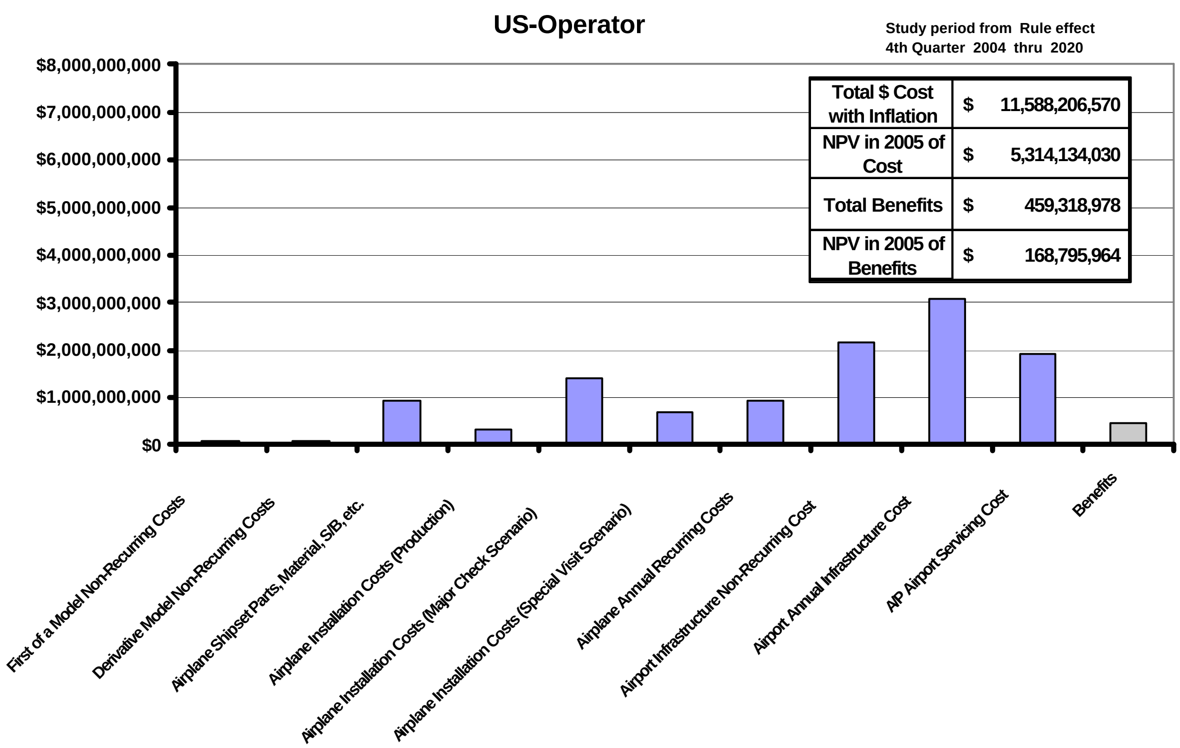

Figure 5-14. Scenario 12—Ground-Based Inerting, All Fuselage Tanks, All Transports (U.S.)

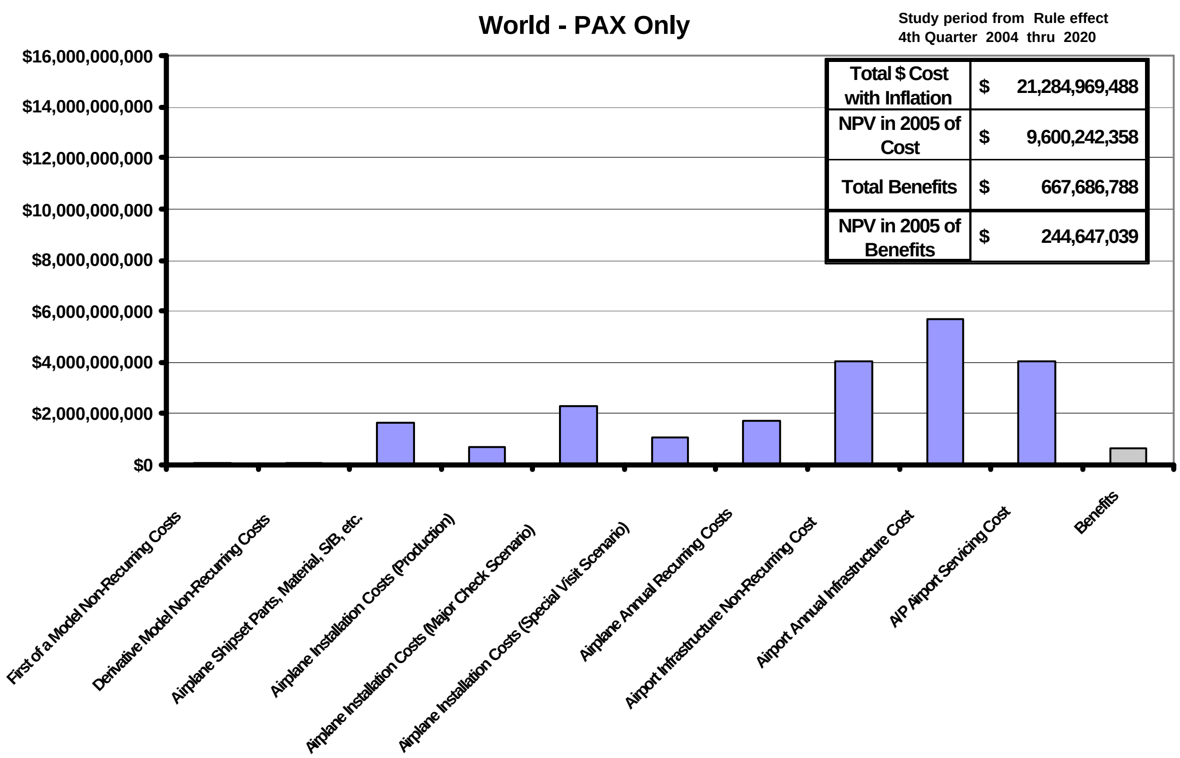

Figure 5-15. Scenario 11—Ground-Based Inerting, HCWT Only,All Transports (World, Passenger Only)

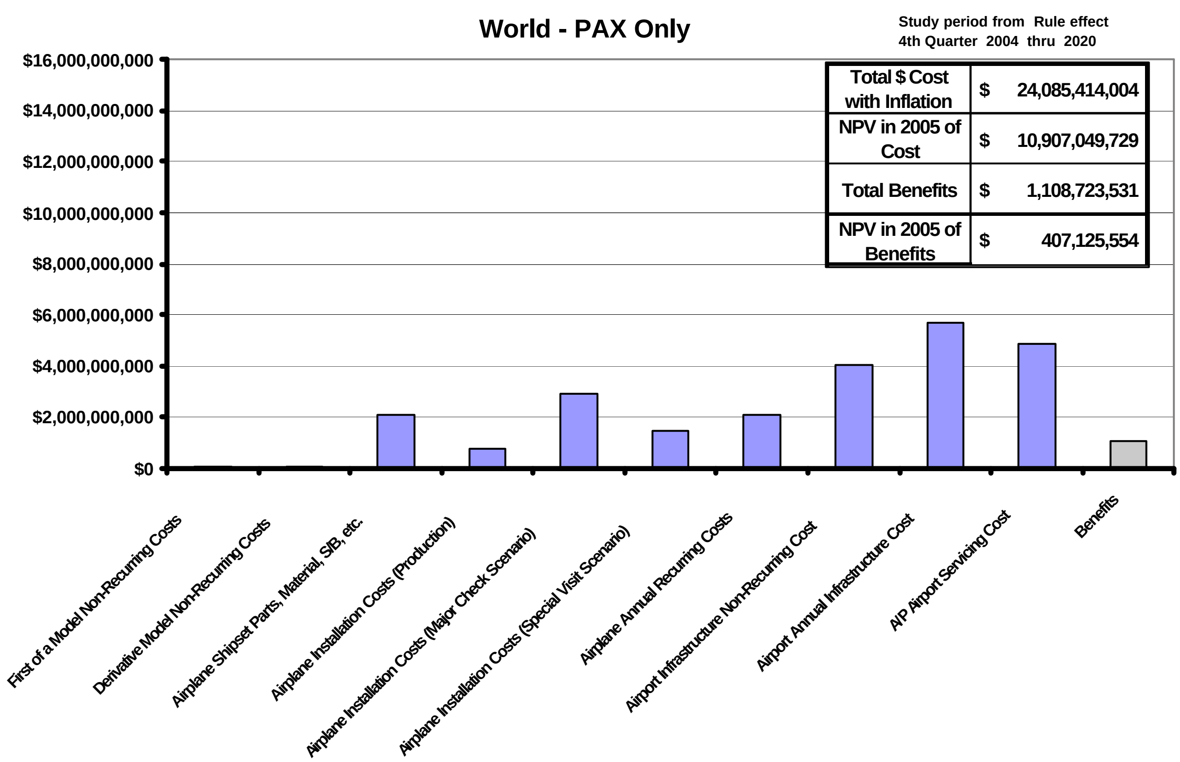

Figure 5-16. Scenario 12—Ground-Based Inerting, All Fuselage Tanks, All Transports (World, Passenger Only)

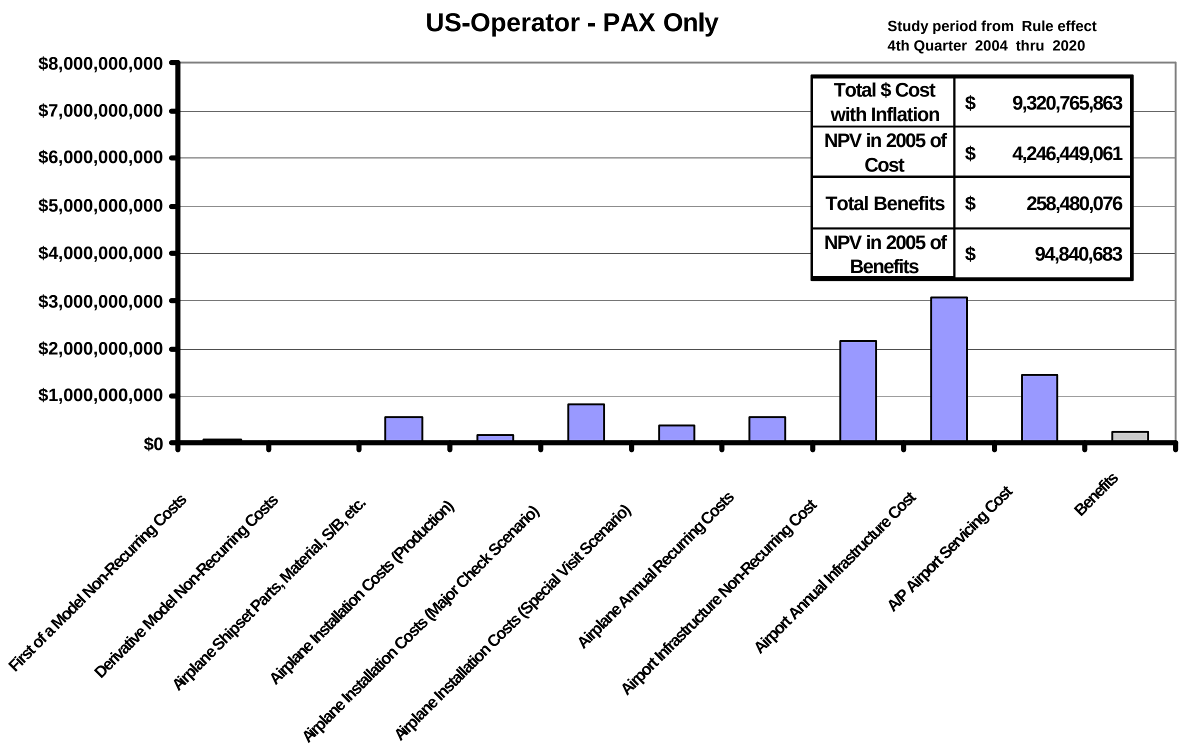

Figure 5-17. Scenario 11—Ground-Based Inerting, HCWT Only, All Transports (U.S., Passenger Only)

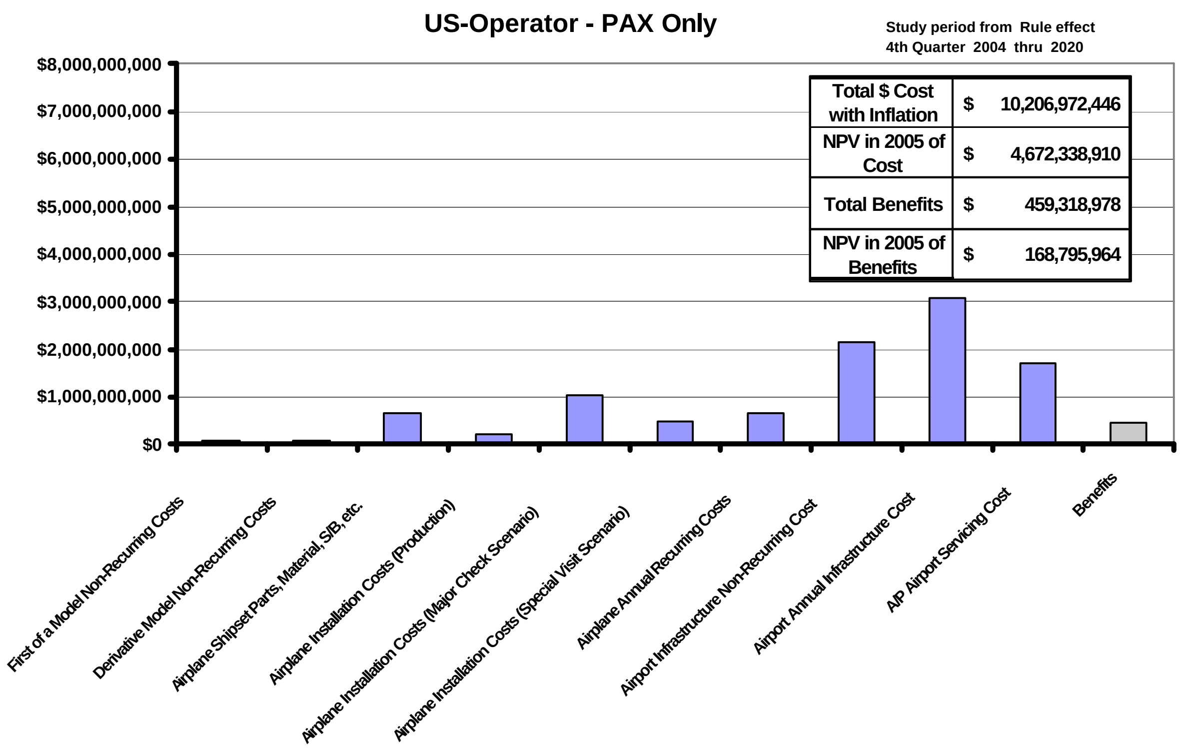

Figure 5-18. Scenario 12—Ground-Based Inerting, All Fuselage Tanks, All Transports (U.S., Passenger Only)

5.7 PROS AND CONS

Pros

- Reduces flammability exposure.
- Simple, with the least impact to the airplane.
- Involves little technical complexity on the airplane.
- Uses current technology components.
- Does not introduce any new installation technology.
- Uses straightforward system operation, in that it is not performed in sequence with the refuel operation and does not require any knowledge of the actual fuel load.

Cons

- Does not remain inert for 100% of the flight cycle. Introduction of air resulting from fuel consumption may still be flammable during ground time after landing but before inerting on hot days.
- Depends on significant airport infrastructure.
- Requires low NEA supply pressure to avoid overpressurizing the airplane fuel tanks if the overpressure system fails.
- Needs new standard airplane interface coupling.
- Amount of NEA supplied may be in excess of that required to achieve the inert levels when the tank is already partially or completely full.
- Requires unique maintenance practices.
- Increased VOC emissions during the fueling process.

5.8 TECHNICAL FEASIBILITY

5.8.1 New Designs

There are no major concerns with the concept for newly designed airplanes if GBI is integrated early in the design phase. During the design cycle, the system would be subject to design reviews, safety assessment, zonal analysis, and so on. The basic design phase will finalize the manifold design, structural penetrations, wiring, and service-point location. Electrical controls and circuits associated with the inerting system equipment need to be routed so as not to introduce any new hazards. Location of the filling point would take into consideration not just the positioning of the servicing trucks but also their location, so as not to introduce additional hazards in the event of a wheels-up landing. Accessibility of the filling connection would take into consideration the acceptability of servicing steps or a platform, if necessary.

5.8.2 In-Production Airplane Designs

Optimum manifold design in terms of weight and location may not be possible because of other installed systems or limitations on location of structure penetrations. Certain airplane types may require modifications to tank venting arrangements, which would require additional design and certification activity over and above that required to demonstrate the effectiveness of the modification in inerting the tank. Location of the servicing connection point may require redesign of a section of the external airplane body fairing, possibly including the introduction of a dedicated panel granting access to the servicing point. Airline spares will be affected.

5.8.3 In-Service Airplane Retrofit

These same possible redesign concerns apply equally to airplanes already in service needing to be retrofitted with GBI. Modification to the tank installation or areas around the fuel tank made to the airplane since the original delivery may require further additional design work and adaptations.

Auxiliary Tank Installations

Generally, these concerns also apply to auxiliary tanks, as do several additional concerns.

- The need for double-walled tubing in the pressurized areas will further complicate tube routing in areas where space is constrained by other systems.
- More than one auxiliary tank will require a balanced flow of NEA between the tanks. This may require an NEA volume greater than the 1.7 times the total ullage volume currently envisaged, or an additional connection point and control panel.
- Some auxiliary tanks include bladders inside the tanks, which could complicate redesign because of the need for new bladders to accommodate new tubing penetrations and routing in the tank.
- New pipe penetrations will require modification of cargo bay liners.

5.9 MAJOR ISUES AND RESOLUTIONS

A new standard interface coupling, developed and controlled by a recognized authority, would allow the airplane to be purged at any airport location from a ground-based NEA distribution system. The schedule for accepting this standard and the availability of hardware would have to be compatible with the regulatory requirements.

The correct purging of the tank ullage depends on the performance of the ground supply. A specification will be required to control pressure and flow performance and integrity of the ground equipment. The required volume to correctly purge the tank ullage will be defined following airplane tests. Ground equipment will need to be specified before airplane tests can be performed.

Some ground equipment requirements (e.g., delivery pressure) drive the need to consider the demands of retrofitting the system onboard existing airplanes. Ground equipment must be designed so it does not constrain future airplane designs.

5.10 CONCLUSIONS

Installing a GBIS does not require that any new technology be developed, although the low supply pressure of the NEA will require attention to the detailed design of the distribution system. Challenging practical considerations may arise for system retrofit applications (e.g., cutting and reinforcing holes in the tank structure).

The availability of suitable ground equipment, regulatory requirements, airport nitrogen sources, and airport distribution systems will determine the time required to make such a system operational.

Certification will require ground and flight tests on each major airplane model, which in turn will require the availability of airplanes—many of which the original manufacturers do not own—on which to perform the certification tests.

Specific attention must be paid to the special ground equipment and interface connector. Both these items are new and will need to be developed. Development of a new standard will ensure worldwide compatibility. Control of this new standard must be clearly identified.

6.0
Airport Facilities